C.D. Howe Institute
Commentary

ISSN 0001-824

Putting the Brain Drain in Context

Canada and the Global Competition for Scientists and Engineers

Daniel Schwanen

In this issue...

Why we should not be complacent about the departure of highly educated Canadians for the United States.

The Study in Brief...

Canada cannot afford to be complacent about the number of highly educated individuals leaving for the United States, even if the number appears small relative to that of new graduates or immigrants with university degrees. This is true at least in the science and engineering fields that this study more closely explores.

Canada has made tremendous progress in recent decades in catching up to the United States in the number of individuals graduating each year from its universities, including in science and engineering. However, Canada remains far behind the United States in terms of the availability of scientists and engineers with advanced degrees, who are key to research and educational efforts in the high-technology industries that recently have emerged as among the most economically productive in the economy.

Indeed, while Canada has experienced fast employment growth overall in these industries, the types of jobs being created in high-tech manufacturing on this side of the border increasingly have tended to be related directly to the production process, rather than to nonproduction functions such as management, research or sales, in contrast to high-tech jobs in the United States. This calls into question whether Canada can attract leadership at the higher end of the value-added scale in these industries, rather than at the less innovative end.

Canada is making strides relative to the United States in attracting highly qualified permanent immigrants. However, those who leave still impose a cost on Canada, since many are among the most knowledgeable and experienced workers. Moreover, the cost of their leaving may be magnified in today's increasingly knowledge-based economy, in which the recipe for success requires a close sharing connection between such leaders and other members of the team. In addition, the United States does a better job than Canada of retaining its own highly skilled workers, whether one considers temporary or permanent emigration, and it continues to graduate more individuals with advanced degrees than does Canada.

Without exploring in detail the causes of the costly flow of Canadian brains to the United States, the study notes that Canadians working there tend to obtain more employer-provided health and pension coverage than do other foreign-born or native-born workers, and that the existence of good jobs also depends on an economy's ability not only to generate ideas but to use them innovatively. Improvements in that regard will no doubt be related to reform of Canada's tax structure.

The Author of This Issue

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$10.00; ISBN 0-88806-466-7

The past two years have seen a resurgence in Canada of the debate about a "brain drain" to the United States. This debate is generally framed in terms of whether or not skilled Canadians are lured south in worrisome numbers by a more attractive professional and fiscal environment, thereby enhancing the US economy at the expense of Canada's. A corollary question is whether Canada can make up for this outflow with new arrivals from abroad.

The brain drain phenomenon may not seem large relative to the thousands of new university graduates Canada produces or well-educated new immigrants that arrive each year. The question I explore in this *Commentary* is whether "not large" also means "unimportant" in today's economic climate, when Canada's ability to compete in knowledge-based industries is paramount. I focus particularly on scientists and engineers and on the high-technology industries that intensively employ them.

Some analysts (for example, Helliwell 1999; Canadian Association of University Teachers 1999) have suggested that there is no cause for alarm. I conclude, however, that Canada cannot be complacent about the number of highly educated workers that leave the country each year. Although Canada now seems to have surpassed the United States in the number (relative to its population) of annual graduates with science and engineering degrees, the number with advanced degrees in these fields remains proportionally considerably higher in the United States than in Canada. Moreover, a disproportionate number of those who leave Canada seem to be at the top end of the skills or income spectrum. Canada attracts more skilled immigrants than does the United States, but it is reasonable to suggest that the United States does a better job of retaining its own skilled workforce. Furthermore, relative to the US experience, high-tech manufacturing activities in Canada seem to be concentrated more in physical production than in nonproduction functions such as management, sales, or research. In this context, the departure of even a modest number of highly skilled workers may contribute significantly to Canada's lagging economic performance *vis-à-vis* its southern neighbor.

A full analysis of the reasons for this outflow of educated Canadians is beyond the scope of this paper. I believe, however, that a reasonable debate on the causes of the problem should pay as much attention to the roots of growth and innovation in the business sector as to reduced personal taxation or increased government funding of knowledge-intensive activities, the two factors on which most public discussion of this issue has focused so far.

Outline of the Commentary

In the first two brief sections, I outline the issue of the brain drain phenomenon, and discuss the new knowledge economy and why highly educated workers are so important to it. Turning to scientists and engineers specifically, it is important to assess the question of whether Canada's net "brain gain" from other countries sufficiently compensates for its losses to the United States in light of the availability from all

The author thanks Don Daly, Don DeVoretz, Jack Mintz, Kari Norman, Finn Poschmann, Bill Robson, David Stewart-Patterson, Lori Whewell, Shane Williamson, and others who wish to remain anonymous for their helpful comments. The author is solely responsible for the paper's conclusions and any remaining errors.

sources of these knowledge workers in both countries. In the next section, therefore, I examine the existing stock of such workers in the two countries in both quantitative and qualitative terms. I then look at the relative pace at which the annual flow of workers into and out of the Canadian and US economies adds to the stock, and which country appears to be gaining as a result. Following this assessment, I examine employment trends in the high-tech industries that employ scientists and engineers most intensively.

Is the brain drain, thus contextualized, a cause for worry in Canada? In the next section, I explain why my answer is yes. Finally, I offer a few thoughts on the underlying causes of this troublesome southward movement of some of Canada's best and brightest, before providing a concluding summary.

A Summary of the Issue

Up to 10,000 Canadians with university degrees move to the United States each year.

Statistics Canada estimates that up to 10,000 Canadians with university degrees (in all fields) move to the United States each year (Canada forthcoming). This number includes some individuals who may, in fact, return to Canada at a later date, as well as highly qualified Canadians who are temporarily employed in the United States and who have been resident there for at least six months. Any sensible brain drain estimate should also include emigration to the rest of the world, which Statistics Canada estimates to be roughly twice the number of departures for the United States (Fellegi 1999).

Relative to the number of new Canadian university graduates (about 128,000 a year) and the total number of immigrants with university degrees entering Canada (about 51,000 each year) (see Canada 1998, table 33; 1999b, 9), the number of university-educated leavers to all destinations does not seem large. But, as I will argue, it is nonetheless significant.

I am primarily concerned in this paper with the movement of two important subsets of Canada's highly skilled workers: those with university degrees in the natural and physical sciences, mathematics, and engineering (henceforth referred to as science and engineering), and workers in the so-called high-tech industries.

This choice is motivated by two generally accepted facts. First, the amount of research and development (R&D) — involving a high number of science and engineering workers — that occurs in Canada is considerably smaller relative to the size of the economy than it is in many other advanced countries (see OECD 1999, table 5). Second, Canada's disappointing productivity relative to its main competitor, the United States, over the past decade or so stems in considerable part from the strong US advantage in a few key high-tech industries that rely heavily on R&D activities and hence on workers with specialized science and engineering knowledge (see Canada 1999l, 4; Sharpe 1999, table 3).

The Role of Knowledge Workers in the Economy

The most recent body of work on the subject strongly suggests that economic growth relies increasingly on the ability to employ scientific and technological knowledge in productive ways. As Lavoie and Finnie note (1998, 2), the fact that "scientific and technological activities are bread-and-butter for achieving economic growth" has been

well documented. The corollary is that the presence of workers who possess the ability to develop, absorb, or diffuse new ways of doing things has a positive effect on an economy's overall ability to generate growing incomes.

It is this ability to use its knowledge productively — which depends, in turn, on such factors as good management and entrepreneurial activity — that allows an economy to compete without low wages or a reliance on natural resources; that is, to both compete successfully and raise the average standard of living of its population. The activity of knowledge workers, managers, and entrepreneurs provides the general social benefit of raising the productivity and income of the overall population above and beyond these individuals' own (private) remuneration.[1] Indeed, such social benefits have always been a key argument in favor of public funding for higher education and research efforts.

Education, knowledge, and technological entrepreneurship have become increasingly important to the Canadian economy in recent years.

Education, knowledge, and technological entrepreneurship have become increasingly important to the Canadian economy in recent years. The natural resources that traditionally have been Canada's source of wealth provided a declining share of Canadians' incomes in the 1990s, but significant "education premiums" — higher wages, better employment opportunities, or both, for those with more education — are found in the Canadian and other labor markets. Even though those premiums have fallen somewhat in Canada in recent years for younger graduates, the pool of educated workers has grown significantly with the coming of age of the most highly educated generation in Canadian history.[2]

Taking Stock of Scientists and Engineers

Thus, the availability of knowledge workers is essential in both Canada and the United States, and it is in this context that I begin my analysis of Canada's "brain competitiveness" by attempting an inventory of university-educated science and engineering human resources in the two countries.

Quantity

The available data on the stock (that is, the number) of skilled workers in Canada and the United States are summarized in Table 1. The numbers include all individuals with at least a bachelor's degree in the disciplines mentioned, expressed both as absolute numbers and as a proportion of the population aged 21 and over.

The table reveals that Canada has a small deficit (less than 4 percent) in the number of scientists and engineers with university degrees. The small size of this differential reflects the progress Canada has made over the years in closing the gap between its higher education enrollment rates and those of the United States (the enrollment rate is defined as the percentage of the population aged 15 to 24 attending school); this gap was as much as 7 percentage points 20 years ago (see Fortin 1999, 80). As we shall see, however, Canada has also relied on the heavy inflow of university graduates from abroad to narrow its knowledge-worker deficit.

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1 See Scherer (1999, 36–42) for a good short primer on these "spillover effects."

2 For global evidence of differences in labor market outcomes by level of education, see OECD (1998, 340–345, 351–363); for the Canadian situation, see Kapsalis, Morissette, and Picot (1999).

Table 1: ***Stock of University-Educated Scientists and Engineers,[a] Canada and the United States, 1996***

Field of Degree	Canada		United States	
	Number	As Percentage of Population Aged 21 and Over	Number	As Percentage of Population Aged 21 and Over
	(thousands)	*(percent)*	*(thousands)*	*(percent)*
Agriculture, forestry	37.8	0.18	304.9	0.16
Biology	101.5	0.47	1,004.3	0.54
Engineering	262.0	1.21	2,247.3	1.21
Chemistry, physics, geology	73.8	0.34	632.1	0.34
Other science, mathematics, computers	140.2	0.65	1,276.2	0.69
Total	615.3	2.85	5,464.8	2.95

[a] Excluding management and social sciences.

Note: Both Canadian and US data sources for scientists and engineers include those who received university degrees in the fields identified here, whether or not they are active in the labor force. However, the US data exclude scientists and engineers over age 75 and those who are institutionalized.

Sources: *Number of scientists and engineers in Canada*: Canada 1999f.

Number of scientists and engineers in the United States: United States 1999e. This survey follows up on several earlier ones: the 1993 National Survey of College Graduates; the 1993 National Surveys of Recent College Graduates and its 1997 Follow-Up Survey; and the Survey of Doctorate Recipients, all sponsored by the National Science Foundation's Scientists and Engineers Statistical Data System. Although the survey was conducted in 1997, it excludes those who obtained their first college degree after June 30, 1996, and anyone living in the United States whose first science and engineering degree was obtained abroad after April 1, 1990.

Population: Canada 1999i; United States 1997b.

Quality

The difference between Canada and the United States regarding the number of science and engineering university graduates widens considerably if one considers quality as well as quantity — the United States is well ahead in terms of those with an advanced degree (see Table 2). Relative to its population of postgraduation age, the United States has approximately 18 percent more individuals with master's degrees in science and engineering fields, and 22 percent more with doctorates, than Canada does. As the table shows, the US lead exists across most science and engineering fields.

The US lead exists across most science and engineering fields.

There are many reasons why this lag in workers with advanced degrees is worrisome for Canada. Universities depend on this highly educated group for their teaching and research activities, and hence they play a vital role in the formation of science and engineering personnel and in spreading the benefits of scientific knowledge throughout various industries and to the Canadian public at large. The education premium, which exists for university-educated individuals generally, is substantially higher still for those with advanced degrees (Ontario 1999, figure 3). In short, when discussing Canada's ability to generate high living standards in the new knowledge-based labor market, one must now look beyond the number of individuals with a single university degree in a relevant field.

Furthermore, Tables 1 and 2 refer only to very broad skills categories. There are some significant differences between the two countries within each of these categories that the tables do not show, partly because detailed comparisons cannot easily be made

Table 2: ***Stock of Individuals with Advanced Science and Engineering Degrees,[a] Canada and the United States, 1996***

Field of Degree	Canada		United States	
	Master's and PhD	PhD Only	Master's and PhD	PhD Only
	(number per 100,000 population aged 21 and over)			
Agriculture, forestry	38	9	31	12
Biology	114	47	150	78
Engineering	286	51	318	58
Chemistry, physics, geology	134	66	125	67
Other science, mathematics, computers	124	29	200	31
Total	696	202	824	246

[a] Excluding management and social sciences.

Note: See Table 1

Sources: See Table 1.

for all degree fields. But Canada is proportionately well ahead of the United States in the number of individuals with university degrees in forestry, mining engineering, resources, and environmental engineering, whereas the United States has a large lead over Canada in aerospace, electrical, and industrial engineers. Such specialization patterns are to be expected, given Canada's comparative advantage in natural resources, but this advantage is becoming less important in world markets. Canada's future growth prospects depend less on its immobile natural endowments and more on knowledge-intensive, geographically mobile activities, and Canadians should be concerned about the extent to which degree-holding patterns reflect Canada's relative weakness when it comes to graduating or retaining individuals with skills that are in increasingly high demand.

For example, the United States has 50 percent more electrical and computer engineers per capita than does Canada (see Reallocation Steering Committee 1998, 10). This statistic alone is telling, given the continuing spread of information and communications technologies across virtually all economic activities, a phenomenon that economist Richard Lipsey has compared to the importance of the water wheel, writing, and other "general-purpose" technologies whose emergence caused "deep structural adjustments and massive changes in our way of life as well as rejuvenating the growth process" (1996, 21).

Economist Richard Lipsey calls the spread of information and communications technologies a phenomenon as important as the water wheel and writing.

Is the Gap Closing?

Is Canada closing the gap, relative to the United States, in terms of the availability and the credentials of highly qualified scientists and engineers? The answer depends not only on what is happening to bilateral Canada-US movements of such individuals, but also on other, often quantitatively more important flows. Do proportionately more US students than Canadian ones graduate in these fields? Does the United States attract more foreign talent? Is that country better at retaining its domestic talent? And is the talent of comparable quality? Responding to these questions requires, first, a look at the

movement of science and engineering personnel into and out of both countries, and then an attempt to assess this labor force in a qualitative sense.

Quantity

The change in the availability of university-educated scientific workers in any country over a given period can be defined as: the number of new graduates during the year in the relevant fields (less the number of foreign students graduating), plus the permanent inflow of highly skilled workers from abroad during the year (including foreign students who become permanent residents) and the change in the number of foreign highly skilled individuals temporarily residing in the country, minus the number of highly skilled individuals who retire from the work force or emigrate permanently to other countries, and any increase in the number who take up temporary employment in foreign countries.

Unfortunately, there are no consistently defined statistics on these movements of knowledge workers even within Canada or the United States, let alone between the two countries. In order to assess whether or not Canada has a brain competitiveness problem *vis-à-vis* the United States, I attempt to make such a comparison here. I have not tried to reproduce precisely the actual movement of these workers in any given year but, rather, to illustrate a plausible scenario of the current flow of science and engineering graduates based on recent experience. The result of this exercise is summarized in Table 3. (Because assumptions play an important role in the picture presented here, the reader is particularly invited to refer to the detailed source note to the table.)

The main message of Table 3 is that, if "highly skilled science and engineering workers" are defined as those holding a bachelor's degree obtained anywhere in the world, Canada compares favorably with the United States in terms of both the number of students graduating and the number of immigrants it attracts. Recent numbers suggest that, as a proportion of the number of individuals reaching typical graduation age (which is 22 in both countries), more Canadians than Americans now graduate with degrees in science and engineering. With respect to immigration, the Canadian number I use reflects a surge in immigrants who had science and engineering as their selected occupation in 1996; in that year, well over a third of university-educated immigrants to Canada held degrees in science and engineering.

The United States is probably better than Canada at retaining its scientists and engineers.

The United States is probably better than Canada at retaining its scientists and engineers, as it does its population generally,[3] and recently has also seemed to attract more temporary workers than its northern neighbor. The numbers shown in Table 3 are derived partly from estimates of emigration and temporary movements among highly qualified personnel, which are far less reliable than the immigration data but give a solid idea at least of the orders of magnitude. And although the flow of temporary workers is by nature volatile, over the years a growing number of Canadian temporary

3 This seems a reasonable conclusion since US emigration, as well as being much lower than Canada's overall, is overwhelmingly made up of those not born in the United States (80 percent); moreover, of those about half return to countries with much lower income per capita than the United States (Ahmed and Robinson 1994, table 9). Those returning to low-income countries are, on balance, unlikely to have accumulated significant human capital in the United States (ibid.).

workers, intracompany transferees, and students have converted their temporary status in the United States to permanent residency (DeVoretz and Laryea 1998, table 4). The increase in the southward flow of temporary workers could thus be a harbinger of increased permanent emigration.

The overall conclusion one can draw from Table 3 — even taking into account that 1996 seems to have been an exceptionally strong year for immigration into Canada — is that, if the trends reflected there continue, Canada could catch up to the United States in the number of individuals with science and engineering degrees as a share of the adult population within as little as three years.

Quality

As I have already observed with respect to the stock of scientists and engineers, a markedly different picture can emerge when one measures, even roughly, the quality of the knowledge labor force than when one simply focuses on the numbers. And as was the case with counting the stock of engineers and scientists, there are indications that, in terms of the flows of these individuals, Canada is losing out when one takes into account the quality, not just the quantity, of the migrating workers. Six key observations point to this conclusion.

Canada is losing out when one takes into account the quality, not just the quantity, of the migrating workers.

First, a noticeable difference continues to exist in the number of advanced degrees granted in the two countries. In the United States in 1996, master's degrees were granted to more than 12 percent of resident graduates aged 24 (the typical graduating age for this degree), but in Canada to only 5 percent of graduates of the same age. Similarly, the number of doctorates granted in the United States per resident graduate aged 27 (the typical graduation age for such degrees) was nearly double that in Canada (0.9 versus 0.5; see OECD 1998, table C4.2b). Although these ratios represent an average for all university programs, they also appear to favor the United States in science and engineering, even if one takes into account the very high proportion of foreign students in such programs there.[4]

Second, given that Canada relies heavily on immigration to keep up with the United States in terms of its stock of scientists and engineers, the extent to which immigrants are actually able to experience labor market outcomes that reflect their *ex ante* work expectations can be a significant factor in determining the extent of this brain gain from abroad. The 1996 Canadian census showed that, among immigrants who arrived between 1990 and 1994, about 20 percent of those who had declared science and engineering fields as their intended occupations when they arrived were not working in such occupations in Canada at census time (Fellegi 1999). This may be a sign either that these workers are not being integrated successfully into the Canadian labor market in their intended occupation or that highly skilled immigrants are using Canada as a

4 Even assuming that 34 percent of US science and engineering graduates are foreign-born (the 1994 figure) and that only 18 percent of Canadian graduate in those fields are (the average of foreign graduate students enrolled as a percent of total enrollment in *all* graduate programs in Canada in 1996), then removing the foreign students in both countries would still leave the ratio of graduate to bachelor's degrees granted in science and engineering 20 percent higher in the United States than in Canada (calculations from United States 1998, tables 251 and 252; Young 1998; Canada 1998, tables 37, 39, 40). In any event, one study estimates that, in 1996, at least 20 percent of foreign students in the United States converted their status to that of permanent resident (Lowell 1999, 14).

Table 3: ***Annual Flow of Science and Engineering Workers Into and Out of Canada and the United States, A Typical Recent Scenario[a]***

	Canada	United States	Factor
		(thousands)	
Inward flow			
New graduates	26.6	221.3	8.3
Permanent immigrants	18.0	18.6	1.0
Change in in-bound temporary residents	1.3	8.2	6.3
Outward flow			
Foreign students graduating	2.5	17.7	7.1
Permanent retirements	4.8	43.2	9.0
Permanent emigrants	1.4	1.6	1.1
Change in out-bound temporary residents[b]	1.8	0.8	0.4
Net change	*35.4*	*184.8*	*5.2*
Note: total population (December 1995)	30,537	264,038	8.6

[a] Workers with a bachelor's degree or higher in science, excluding the social sciences.

[b] Bilateral Canada-US flows only.

Sources: *New graduates, Canada*: The estimate assumes a continuation of 1992–96 trends in the number of graduates per population of graduating age reported in Canada (1999i). Graduates in the following fields were included: agriculture and biological sciences, engineering and forestry, chemistry, geology, physics, other physical sciences, and mathematics and computer science.

New graduates, United States: The figure was estimated assuming that 22-year-olds graduate that year in engineering, natural sciences, and mathematics and computer science at the same rate as in 1996, as reported in OECD (1998, table C4.4). The ratio of engineering graduates was estimated by taking the total ratio for engineers and architects as reported by the OECD and reducing it by the actual share of architects among 1995 graduates in these two disciplines as reported in National Center for Education Statistics (1999, table 266). A small upward adjustment was also made to correct for the underreporting that would have resulted had I followed this procedure to estimate 1995 science and engineering graduates, relative to the actual number of graduates according to the NCES (ibid.).

Foreign students in Canada: The figure is based on the percentage of foreign students in total higher education enrollment in 1996. Data are from Canada (1999j), multiplied by the same factor as for the United States (below).

Foreign students in the United States: This figure is based on the percentage of foreign students in total higher education enrollment in 1993–94, multiplied by 2.5 to reflect the higher ratio of foreign graduates in science and engineering relative to other graduate programs that year, and applied to the number of new graduates above. The assumption is that foreign students are as overrepresented in science and engineeering bachelor's programs as they are in graduate programs. Data are from United States (1999d, tables 172, 251, 252, and 414).

Permanent immigrants to Canada: The figure is the number of immigrants reporting "natural sciences, engineering and mathematics" as their intended occupational group in Canada in 1996, less architects and other architecture and engineering workers (such as draftsmen). Data are from Canada (1999a, table IM20).

Permanent immigrants to the United States: Data are from United States (1999a, table 5), and include the categories "engineers, surveyors, and mapping scientists," "mathematical and computer scientists," and "natural scientists." [*Notes continue.*]

Notes to Table 3 - continued

Inbound temporary residents in Canada: The figure represents the increase in the stock of foreign workers employed in the Immigration Canada category "professional occupations in natural and applied sciences," 1998 over 1996 annualized. These occupations constituted 25.5 percent of the stock of temporary professional foreign workers in Canada on average during those two years. Data are from Canada (1999c, 16).

Inbound temporary resident in the United States: The figure represents the increase in the number of temporary workers entering under speciality occupation (H1B) visas, 1996 over 1994 annualized, and of professional workers under NAFTA (TN) provisions, 1997 over 1994 annualized, divided by four to account for the fact that US statistics count admissions (of which there can be multiple ones under a single visa) rather than visas issued (it is estimated that, in 1996, one H1B visa issued yielded 2.5 admissions on average; the ratio of 4 that I use here assumes, therefore, a higher rate of multiple crossings for TN visa holders; see Lowell [1999, 11 and table 1]), and further divided by 4 to mirror the share of science and engineering workers in Canada's temporary foreign population; plus the increase in intracompany transferees (L1 visas), also divided by 4. The data are from United States (1999c, table 39). The assumption is that, as a proportion of the total number of in-bound temporary highly skilled residents, the United States attracts the same share of scientists and engineers as does Canada. Note that the United States has recently authorized the entrance of a much higher number of temporary workers in high-tech occupations, which is not reflected in this estimate.

Permanent retirements in Canada: The figure is the estimated population aged 63–67 with university degrees in 1996, multiplied by the percentage of science and engineering degrees among the total population with university degrees in 1996.

Permanent retirements in the United States: To reach this figure, scientists and engineers are assumed to retire at an annual rate equal to one-tenth of the percentage of scientists and engineers who graduated during the 1950–59 period among the entire science and engineering population (which includes, for example, social scientists); this yields a retirement rate of close to 0.8 percent of the existing stock (7.9 percent of which graduated during the 1950–59 period).

Permanent emigrants from Canada: The data are an update of those used in Fellegi (1998) for the annual number of engineers, mathematicians, computer specialists, and natural scientists emigrating to the United States, averaged over the 1995–97 period, multiplied by two to account for emigration to other countries (as suggested by Fellegi for overall emigration).

Permanent emigrants from the United States: The figure was derived by multiplying the equivalent Canadian number by 4.8 (the ratio of estimated total US emigration to estimated total Canadian emigration for all of the 1980s, the last time that US estimates were updated), then dividing by 4.2, which is the ratio of Canadian emigration of scientific and engineering personnel to the United States to the flow of such personnel from the United States to Canada during the 1990–94 period. The assumption, therefore, is that the United States is not losing proportionately more highly skilled personnel to the rest of the world than it is to Canada. See also note 3.

Outbound temporary residents from Canada: This figure is the share of Canadians entitled to stay in the United States under H1B, TN, and L1 visas in fiscal year 1996 (United States 1997, table 40), multiplied by the average annual increase in all temporary scientists and engineers in the United States under these visas as estimated above for the 1994–96 period.

Outbound temporary residents in the United States: This figure is derived from the Canadian number, multiplied by the ratio of temporary US entrants into Canada to Canadian temporary entrants into the United States under NAFTA provisions in 1996.

Population: OECD 1998, table X2.1

stopover on their way to the United States. In either case, Canada may not obtain the benefits suggested by the number of immigrants shown in Table 3.

Third, it also appears that, although Canadian-born professionals in the United States experience labor market outcomes at least on par with their US-born counterparts, immigrants to Canada need, on average, an adjustment period of ten or more years before they match the performance of their Canadian counterparts. They also require more language training and other settlement costs (DeVoretz and Laryea 1998, 21; Statistics Canada notes that a similar period of adjustment holds for computer scientists in particular [Canada forthcoming]). This mismatch between leavers, who settle quickly into US life, and their labor market replacements, who require more resources before they can participate fully in Canada's economy, adds a "churning cost" to the Canadian economy, to the extent leavers must be replaced. Thus, although immigration is beneficial to the Canadian economy, it does not, by itself, negate the cost of science and engineering emigration.

Although immigration is beneficial to the Canadian economy, it does not, by itself, negate the cost of science and engineering emigration.

Fourth, a Statistics Canada survey published by Human Resources Development Canada (HRDC) shows that, although only 1.2 percent of the class of 1995 (about 3,800 individuals from all fields of study) were living in the United States by March 1999 (4,600 left initially but 830 returned in the interim), those who did move south were more likely to have master's degrees or PhDs and were more likely to have been graduates in health,[5] engineering, or mathematical fields than those who remained in Canada. In March 1999, 12 percent of 1995 PhD graduates from Canadian universities were living in the United States. Furthermore, 44 percent of these ranked themselves as being in the top 10 percent of their graduating class (Canada 1999d).

Fifth, with respect to experienced workers rather than new graduates, there are worrisome indicators that those most likely to move to the United States are those with higher-than-average skills or responsibility levels. Indeed, the probability that a Canadian will leave for the United States rises with his or her income. And senior university professors (as opposed to entry-level or mid-career professors) who relocate are more likely to leave for the United States than for another Canadian university (Fellegi 1999).

Sixth, individuals with science and engineering skills, or with management skills in science- and engineering-intensive sectors, are paid better and experience lower unemployment rates in the United States than in Canada (Personnel Systems 1999; Canada 1999e). It is not known how much of this discrepancy is due to these individuals' particular skill levels and how much to other factors, such as relatively high productivity levels or the tighter job market in the United States. Based on experience in the information technology sector, wage differentials between the two countries are highest for more experienced workers. But the job situation for younger graduates also favors a move south; as the HRDC study (Canada 1999d, x) notes, "[c]ompared with graduates who remained in Canada, those who moved to the US tended to find work that was more closely related to their fields of study, required higher skill levels, and paid higher salaries."

In short, although Canadians can take comfort from the increasing supply of graduates in science and engineering fields in recent years, this needs to be tempered by

5 This study does not include health in the definition of science and engineering degrees.

an awareness that any "qualitative" gap does not appear to be closing as quickly — if at all.

The above observations not only suggest that leading-edge talent is much more available in the United States; they also raise a more subtle question about whether the available talent is deployed as profitably in the Canadian economy as it seems to be in the US economy. To get a firmer handle on this question, I now explore a relevant contrast between Canada and the United States with respect to employment developments in high-tech industries.

Employment in High-Tech Industries: What Are the Brains Doing?

The high-tech industries do not employ *all* the highly skilled, well-paid scientists and engineers, of course, but such a high proportion of their employees come from those disciplines that high-tech industries naturally attract attention when the brain drain issue is discussed. Indeed, one recent US study (Hecker 1999) defines an industry as "high-tech" if, within the industry, both the number of employees engaged in R&D and the number employed in all technology-oriented occupations account for a proportion of total employment in that industry that is at least twice the average for the economy as a whole.[6]

Canadian employment growth in these industries, taken as a group, has actually exceeded that in the United States since 1983 (see Figure 1);[7] today, the share of total employment accounted for by all high-tech industries (including high-tech services) is similar in Canada to that in the United States (7.8 percent versus 8 percent). This fact suggests that, in principle, Canada offers a favorable environment to this knowledge-intensive group of industries. (For a complete list of which industries have been included in my data, see Appendix Table A-1.)

Canada's high-tech operations employ a much lower share of nonproduction workers than their US counterparts.

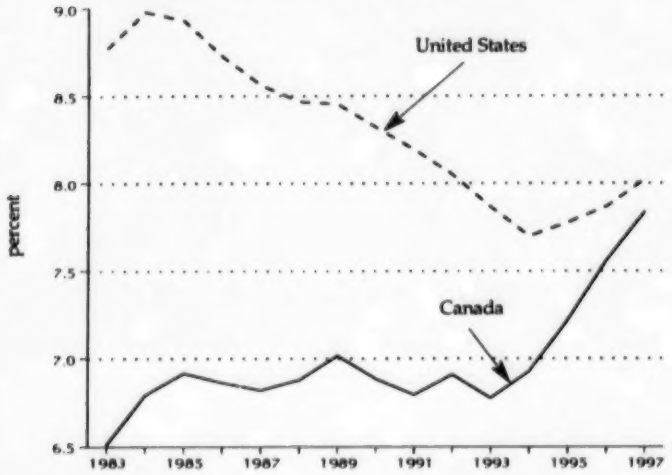
If one looks a little more closely, however, some important distinctions emerge. In the manufacturing sector, for example, Canada's high-tech operations employ a much lower share of nonproduction workers than their US counterparts. This gap between production and nonproduction employees, which has widened over the past 15 years (see Figure 2),[8] is not attributable to a different weighting among these industries in Canada; it exists across almost all high-tech manufacturing industries. Furthermore, while the share of nonproduction workers in US high-tech industries is 11 percentage points higher than in the average manufacturing industry (42 percent versus 31 percent, see Figure 3) and has not changed much over the years, in Canada this differential is only 4 percent (27 percent versus 23 percent), and has fallen over the years.

6 Technology-oriented occupations are defined as engineers, life and physical scientists, mathematical specialists, engineering and science technicians, computer specialists, and engineering, scientific and computer managers.

7 The decline in the high-tech share of US manufacturing employment in the late 1980s was in large part a result of cutbacks in that country's defense industry.

8 Production workers are defined as those "engaged in processing, assembling, storing, inspecting, handling, packing, maintenance, repair, janitorial, and watchmen's services and working foremen" (Canada 1999g, 195); the US definition is similar.

Figure 1 ***Employment in High-Tech Industries as a Share of Nonfarm Employment, Canada and the United States, 1983–97***



Sources: *For Canada*: Canada 1999g. For a list of included industries, see Appendix Table A-1. Since no official estimate was available of the number of production workers by industry for 1987, the number was estimated by averaging the numbers for 1986 and 1988. Numbers for total employment and for employment of production workers in the electronic equipment industries for 1990 were estimated by averaging the numbers for 1989 and 1991.

For the United States: United States 1999d. For 1983–85 and 1987, employment data for industries marked with an asterisk in Appendix Table A-1 are author's estimates, arrived at in such a way as to ensure consistency with known data on the more aggregate series that include the industries being estimated, and with known data on other industries within the same aggregate. Data for 1986 are from Hecker (1999). These industries represented just under 25 percent of total employment in all high-tech industries, and 18 percent in manufacturing. (Details are available from the author.)

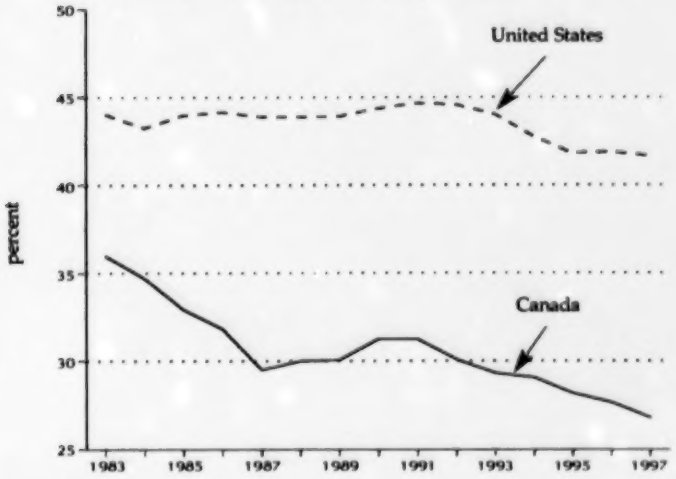
These figures suggest that, in the North American high-tech manufacturing context, operations on Canada's side of the border are far less intensive in occupations such as research, sales, and management than their US counterparts.[9] These high-tech Canadian operations are thus more like other Canadian manufacturing industries in this regard, a fact that evokes a picture in which the traditional hewers of wood and drawers of water of Canadian lore have been replaced by assemblers of cars and computers. These are remunerative activities within the high-tech sector, to be sure, but they hardly indicate a high capacity for innovation. The predominance of the production side of high-tech industries in Canada (relative to the US situation) suggests that global decision-making functions in knowledge-intensive industries are not locating here to the extent warranted by the size of the Canadian economy and Canada's access to the North American market.

The economic impact of these differences is real. To use a simple illustration, in 1997 nonproduction workers in Canada's high-tech manufacturing operations were paid an average of $58,000 while production workers in the same industries received an average of $41,300 (Canada 1999k, table 4; and author's calculations). Thus, Canada's specialization in production activities represented a payroll shortfall in 1997 of $1.37 billion in these industries.

Naturally, this leaves open the question of where Canada's "brains" are, if relatively fewer of them are employed in high-tech manufacturing than is the case in the United States. Since high-tech industries are defined here as those featuring a relatively high number of technology-related occupations in the United States, it is possible that Canada's high-tech sector, if similarly defined within the domestic context, could include some industries not counted as high-tech in the United States. In other words, the comparison made here could show lower numbers of nonproduction workers in Canada's high-tech industries than there actually are. I have not estimated how large this bias might be, but the fact that the gap has also widened for all manufacturing industries suggests that it is not very large. A more complete analysis of Canadian-US

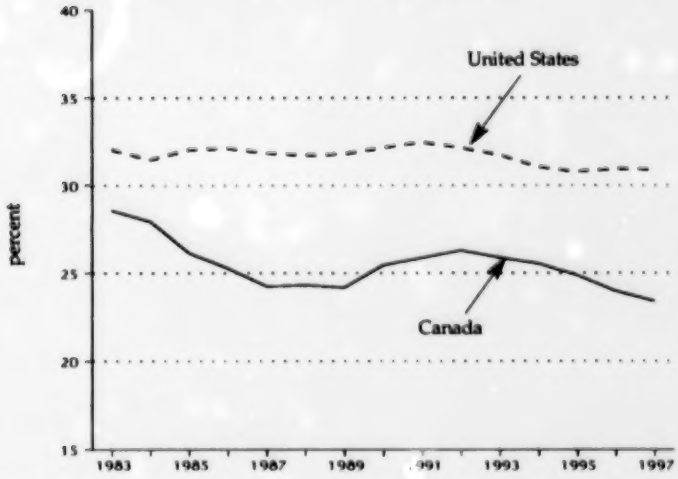
9 Any of these functions may involve science and engineering personnel. In the United States, for example, almost as many individuals with science and engineering degrees are involved in management or sales as in occupations more directly related to science or engineering functions (United States 1999e, table D-13).

Figure 2 ***Nonproduction Workers as a Share of High-Tech Manufacturing Employment, Canada and the United States, 1983–97***



Sources: See Figure 1.

Figure 3 ***Nonproduction Workers as a Share of Manufacturing Employment, Canada and the United States, 1983–97***



Sources: See Figure 1.

differences in manufacturing employment would also have to take into account the services sector and the burgeoning ranks of the self-employed to see whether Canada's "brains" are employed there in some capacity that is complementary to the manufacturing sector in greater proportion than in the United States, instead of being employed in manufacturing operations as such. With respect to R&D functions specifically, it is known that, in Canada relative to the United States, substantially more of them are performed in universities and within governments than in private industry (OECD 1999, tables 17–19). As well, unemployment rates for all major groupings of scientists and engineers are higher in Canada (3.2 percent) than in the United States (1.8 percent). (See Canada 1999e, 16.)

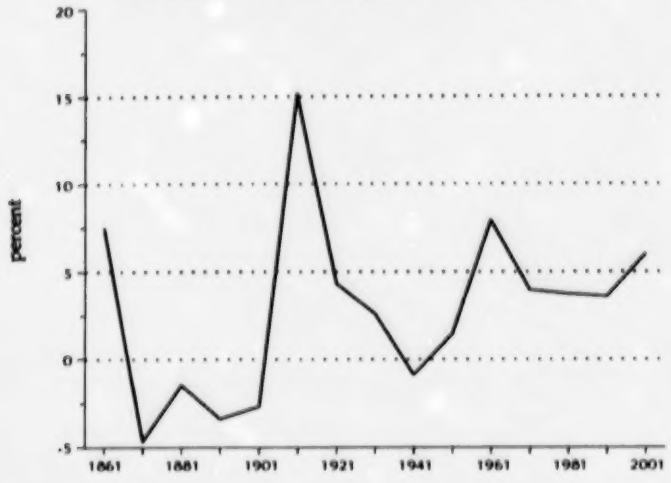
Overall, the United States seems to have the upper hand in deploying nonproduction resources (including scientists and engineers) in the most science- and engineering-intensive, productive, and fastest-growing sectors of its economy, while Canada has been specializing in production work in the same industries.

Why Worry?

Many analysts and commentators have argued that concerns about a few thousand highly skilled individuals departing Canada annually for the United States are overblown. After all, they point out, the rate at which highly educated Canadians are moving south, and the total number of them now living in the United States, is smaller now (relative to the total Canadian population) than historically has been the case — although it is worth noting that the 1990s saw a reversal of a three-decades-long downward trend in this area. Skeptics of the seriousness of the brain drain also note that, even when departures for other countries are included — as they should, when the comparison is with all sources of immigration — more well-educated people are coming to Canada than are leaving it, by a ratio of about two to one. But these facts based on broad numbers hardly refute Canada's relative difficulty in attracting and retaining the most highly skilled individuals, for at least three reasons.

First, Canada traditionally has depended on high levels of immigration for its economic development. Thus, historical comparisons should be made of both the

Figure 4 ***Net Immigration to Canada as a Percentage of Total Population, 1861–2001***



Sources: For 1861–1971 data, Canada 1991, table 3.3; for 1972–98 data, Canada 1999i.

inflow and the outflow of migrants. Although net total inward migration was healthy during the 1990s, such levels are not unprecedented (see Figure 4). Immigration is a volatile phenomenon: the most recent year's figures suggest that the high inbound numbers of the 1989–97 period, on which Table 3 is based, might not be sustained.

Second, Canada's stock of knowledge workers would be higher if, in addition to attracting immigrants, it did a better job of retaining the highly skilled and educated who are already here. If knowledge, as opposed to more traditional factors such as natural resources or an abundance of savings, has become the primary factor for economic growth, Canada may need to be more concerned about the departure of a given number of knowledge workers and managers than it has been in the past.

Third, in the knowledge-based economy, teamwork, which requires a close sharing connection between team leaders and other members of the team, is at a premium. Based on the research of various authors, Rouilleault (2000, 215–216) describes four new organizational requirements brought about by the spread of information and communications technologies: close cooperation between professionals in different disciplines; close cooperation between the project team and future users; cooperation around simulation tools of future work; and project management as key to organizational learning and employee training.

It would thus appear that, despite the increasing ability of knowledge workers to communicate at a distance, countervailing factors that heighten the importance of team work ensure that a concentrated pool of skilled individuals remains critical to the growth of knowledge-dependent industries in a given region, a phenomenon analyzed in detail by Krugman (1991). In this context, it is indeed worrisome that Canada appears to have difficulty attracting individuals who are team leaders at the most productive phases of their careers — and may even be losing a number, though perhaps not a quantitatively overwhelming number, of such people — since co-workers, employers, and even customers and suppliers tend to gravitate toward these "assemblers of knowledge." Leaders in fields as diverse as academia and communications equipment have indicated that they believe this is happening (AUCC 1998; Pearce 1999).

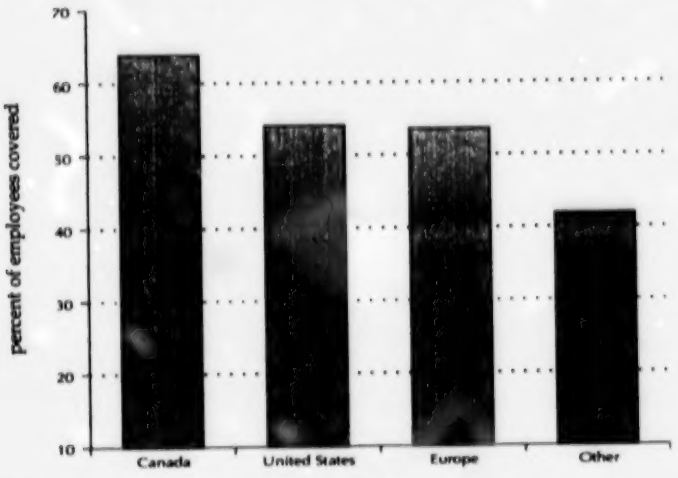
Canada appears to have difficulty attracting individuals who are team leaders at the most productive phases of their careers.

A Few Thoughts on the Causes of the Brain Drain

A complete explanation of why some of Canada's most valuable human resources are leaving the country is beyond the scope of this *Commentary*, but a few observations may be relevant.

Thoughtful people have observed that, if the only motivating factor behind relocation was Canada's high personal taxes, many more people would likely seek

Figure 5 ***Employer-Provided Health Care in the United States: Coverage by Employees' Place of Birth, 1996***



Source: United States 1997a, table 20-3D.

employment opportunities in the United States that offer at least similar pay and then take advantage of the lower tax rates that prevail south of the border. This is not occurring, however, no doubt due in part to the fact that, leaving aside the substantial personal and monetary costs of moving, many Canadians regard their high income tax levels as worth the benefits of the public goods their taxes pay for. All those who publicly worry about the brain drain acknowledge this context, despite efforts on the other side of the debate to portray such analysis as pursuing a self-serving, tax-cutting agenda at the expense of public benefits.

For many Canadians, however, the measure of social protection they would have to sacrifice (presumably in exchange for lower taxes) on moving to the United States is not at all clear. It may be that Canadians who move are able to find employment and other conditions that help offset the loss of public services they enjoyed in Canada. For example, a higher proportion of those who leave Canada for the United States obtain employer-provided health insurance than do other groups of immigrants or even many categories of native-born Americans (see Figure 5). Canadians living in the United States are also well ahead of other immigrant groups in employer-provided pension plan coverage (59 percent, compared with 51 percent for the European-born population and 38 percent for other foreign-born residents in the United States; see United States [1997a, table 20–4D]).

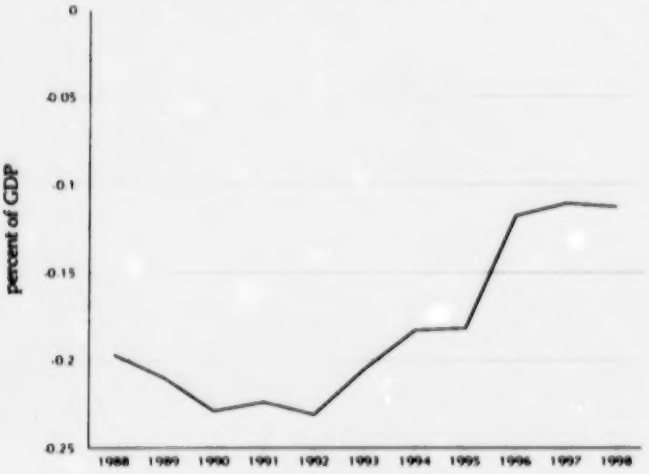
A higher proportion of those who leave Canada for the United States obtain employer-provided health insurance than do other groups of immigrants or even many categories of native-born Americans.

Critics of the tax differential explanation for the brain drain are surely right that the "lack of good jobs" in Canada also figures as an explanation (to the extent they perceive that the number of leavers constitutes a problem), but this hardly settles the issue with respect to taxes. It is clear, for example, from the experience of other countries with well-educated populations but poor economic performance that factors other than the simple availability of "brains" are at play in generating a high standard of living. These include an environment that not only supports private and public R&D efforts, but also rewards the innovative and successful use of the knowledge that highly skilled individuals possess.

This last factor is likely more important than is usually acknowledged. Canada is not "brain dead" — its net international balance on the sale of research, patents, and so on has improved over the years (Figure 6) — but the evidence suggests that better use could be made of this knowledge base to sustain economic activity. Taxing individuals at the highest marginal rate just when their careers in research or project management are taking flight[10] or imposing relatively high business or capital gains taxes on the fruit of these workers' innovative activity cannot help but contribute to driving some of

10 Individuals hit the top marginal rate in Canada at incomes of around $85,000, much more quickly than in the United States.

Figure 6 Canada's Trade Balance in Royalties and R&D as a Percentage of GDP, 1988–98



Source: Canada 1999h; and author's calculations.

Canada's most innovative and successful knowledge workers to create wealth abroad rather than in this country.

However, a review of corporate income taxes is also required to ensure that Canada's intellectual capital benefits all Canadians. As Fortin notes in a recent in-depth review of the problems of Canada's economic performance in the 1990s,

> we should question seriously the inconsistency between having both the most generous R&D tax and grant provisions and the highest corporate tax burden of all G-7 countries. Such a situation may be inviting Canadians and foreigners to set up R&D operations in Canada but then to make use of the results of this activity in manufacturing or services firms established in countries with more favorable corporate tax systems. (1999, 89.)

The glacial pace of corporate income tax reform announced in the February 2000 federal budget is unlikely to address the problem.

If Fortin is right, the glacial pace of corporate income tax reform announced in the February 2000 federal budget is unlikely to address the problem (see Mintz 2000).

It has also been suggested that knowledge-intensive Canadian companies should be more aggressive in their compensation policies if they feel that the loss of key personnel to foreign operations is a problem. Indeed, although Canada ranks second out of 59 countries surveyed by the World Economic Forum in terms of how closely compensation policies are linked with job performance (WEF 1999, table 6.06), it is behind the United States generally in that respect. Again, taxes make it more difficult for employers to be competitive in this area. Because of the higher Canadian "wedge" in income taxes — the gap between what employers pay and what employees receive — Canadian employers have to be more than competitive with their US counterparts in order to attract top personnel, to the extent that that segment of the labor force is mobile and perceives that the higher wedge is not offset by an equivalent difference in public services.

In any event, it is also worth exploring whether Canadian corporations themselves can do better to help recruit and retain highly talented individuals, since there is anecdotal evidence suggesting that many Canadian graduates in high-tech fields are snapped up by US recruiters even before they receive offers from prospective Canadian employers. The renewed focus at the federal level on better integrating immigrants into the work force also has a role to play in matching newcomers to the many high-skilled job openings in Canada that remain unfilled. Canada should at least be more aggressive in looking at whether its tax system can — for a given amount of revenue it generates — help sustain good opportunities in domestic industry for its knwledge workers.

Conclusion

The southward brain flow is more worrisome than the statistics at first suggest.

The 10,000 or so highly qualified brains who leave Canada each year for the United States may not seem like a very large drain, especially since the inflow of university-educated individuals from all foreign sources is estimated to be four times as large. But in the broad context of both the total pool of graduates, particularly in science and engineering, and the Canada-US competition for their skills, the southward brain flow is more worrisome than the statistics at first suggest.

We now live in a world in which the presence of "brains" in an economy seems to make a significant difference to productivity and income growth. The proportion of individuals with advanced science and engineering degrees is considerably higher in the United States than in Canada; the United States retains its scientific population within its borders better than does Canada; and high-tech industries in the United States employ a many more people in managerial, sales, and research functions relative to the total number of employees than do similar industries in Canada — functions that tend to be related to higher incomes than are production jobs. Although Canada attracts proportionately more immigrants, recently even in the science and engineering fields, than its southern neighbor, Canadians cannot be complacent about the number who move south. Evidence suggests that those who go include more than the expected share of the country's best and brightest, and it is the US economy, not Canada's, that benefits from their contribution.

People generally relocate to take advantage of better opportunities, not necessarily because of differences in personal tax rates. But employment opportunities at home in innovative activities by Canada's most productive brains also depends on a supportive tax system. It appears we are not yet there.

Table A-1: ***Industries Classified as "High-Tech" for This Study***

United States	Canada
Inorganic industrial chemicals	
Organic industrial chemicals	Industrial chemicals not elsewhere classified
Drugs	Pharmaceuticals and medicine
Computer and office equipment	Office, store and business machines
Communications equipment*	
Electronic components and accessories	Electronic equipment industries
Aircraft and parts	Aircraft and aircraft parts
Guided missiles and space vehicles	Other transportation equipment (excluding automotive, rail, and shipping)
Search and navigation equipment*	
Measuring and controlling devices*	Indicating and recording instruments
Plastic materials and synthetics	Plastic and synthetic resin
	Soap and cleaning compounds
Soap, cleaners, and toilet goods	Toilet preparations
Paint and allied products	Paint and varnish
Agricultural chemicals	Agricultural chemicals
Miscellaneous chemical products	Other chemical products
Petroleum refining	Refined petroleum products
Engines and turbines	
Construction and related machinery	
Special industrial machinery	
General industrial machinery	Machinery (excluding agricultural and commercial refrigeration)
Electric distribution equipment	
Electrical industrial apparatus	Electrical industrial equipment
Household audio and video equipment	Record players, radio and television receivers
	Motor vehicles
	Truck and bus bodies and trailers
Motor vehicles and equipment	Motor vehicle parts and accessories
Ordnance and accessories	
Medical instruments and supplies*	
Photographic equipment and supplies	Other instruments, related products
Cigarettes	Tobacco products
Pulp mills*	Pulp industry
Other communication services*	
Computer and data-processing services	Computer and related services
Research and testing services*	
Engineering and architectural services	Architectural, engineering, and other science and technical services
Management and public relations services*	Management consulting services

* Employment data for 1983–87 are estimated.

Note: The US list is based on Hecker (1999). The Canadian list differs slightly because of differences in the way sources (such as Statistics Canada) classify industries.

References

Ahmed, Bashir, and J. Gregory Robinson. 1994. "Estimates of Emigration of the Foreign-Born Population: 1980-1990." Working Paper 9. Washington, DC: US Bureau of the Census, Population Division.

Association of Universities and Colleges of Canada (AUCC). 1998. "Fostering a Climate of Innovation." Notes for a statement to the House of Commons Standing Committee on Finance, Ottawa, June 9.

Canada. 1991. Statistics Canada. *Canada Year Book 1992*. Ottawa: Industry, Science and Technology Canada.

Canada. 1998. Statistics Canada. *Education in Canada 1998*. Cat. 81-229-XIB. Ottawa.

———. 1999a. Citizenship and Immigration Canada. *Citizenship and Immigration Statistics 1996*. Ottawa: Public Works and Government Services Canada.

———. 1999b. Citizenship and Immigration Canada. *Facts and Figures 1998: Immigration Overview*. Ottawa: Communications Branch.

———. 1999c. Citizenship and Immigration Canada. *Canada...The Place to Be (Annual Immigration Plan for the Year 2000)*. Ottawa: Communications Branch.

———. 1999d. Human Resources Development Canada. *South of the Border: Graduates from the Class of '95 Who Moved to the United States*. Ottawa: Public Works and Government Services Canada.

———. 1999e. Industry Canada. "Skill Shortages: Beyond the Headlines." *Monthly Economic Indicators*, Special Report, July. Retrieved from Internet website www.strategis.ic.gc.ca/sc_ecnmy/engdoc.

———. 1999f. Statistics Canada. *An Analysis of Science and Technology Workers: Deployment in the Canadian Economy*. Cat. 88-006XIB-99003. Ottawa.

———. 1999g. Statistics Canada. *Annual Survey of Manufacturers: Principal Statistics*. Ottawa: Statistics Canada, Manufacturing, Construction, and Energy Division. October. Unpublished electronic file.

———. 1999h. Statistics Canada. *Canada's International Transactions in Services, 1998*. Cat. 67-203-XPB. Ottawa.

———. 1999i. Statistics Canada. CANSIM Database on CD-Rom, 1999–1 [March]. Cat. 10F0007xcB. Ottawa.

———. 1999j. Statistics Canada. *Education in Canada, 1998*. Cat. 81-229-XIB. Ottawa.

———. 1999k. Statistics Canada. *Manufacturing Industries of Canada: National and Provincial Areas, 1997*. Cat. 31-203-XPB. Ottawa.

———. 1999l. Statistics Canada. "Multifactor Productivity." *The Daily*, March 23.

———. Forthcoming. Statistics Canada. "Brain Drain and Brain Gain: The Migration of Knowledge Workers to and from Canada." *Education Quarterly Review*, cat. 81-003. Ottawa..

Canadian Association of University Teachers. 1999. "Have We Lost Our Minds?" *CAUT Education Review* 1 (July-August).

DeVoretz, Don, and Samuel A. Laryea. 1998. "Canadian Human Capital Transfers: The United States and Beyond." *C.D. Howe Institute Commentary* 115. October.

Fellegi, Ivan P. 1998. "Perte ou Gain de Cerveaux?" Upublished charts for presentation.

———. 1999. "'Brain Drain': What We Know and What We Don't." Presentation to a joint seminar of the Toronto Association for Business Economists and the C.D. Howe Institute, Toronto, September 23.

Fortin, Pierre. 1999. *The Canadian Standard of Living: Is There a Way Up?* Benefactors Lecture, 1999. Toronto: C.D. Howe Institute.

Hecker, Daniel. 1999. "High-Technology Employment: A Broader View." *Monthly Labor Review* (June): 18–28.

Helliwell, John F. 1999. "Checking the Brain Drain: Evidence and Implications." *Policy Options* 20 (7): 6–17.

Kapsalis, C., R. Morissette, and G. Picot. 1999. "The Returns to Education, and the Increasing Wage Gap between Younger and Older Workers." Research Paper 131. Ottawa: Statistics Canada, Analytical Studies Branch.

Krugman, Paul. 1991. *Geography and Trade*. Cambridge, Mass.: MIT Press.

Lavoie, Marie, and Ross Finnie. 1998. "A Dynamic Analysis of the Flows of Canadian Science and Technology Graduates into the Labour Market." Science and Technology Redesign Project, Working Paper ST-98-04. Ottawa: Statistics Canada.

Lipsey, Richard G. 1996. *Economic Growth, Technological Change, and Canadian Economic Policy*. Benefactors Lecture, 1996. Toronto: C.D. Howe Institute.

Lowell, B. Lindsay. 1999. "Skilled Temporary and Permanent Immigrants in the United States." Working Paper 99-S2. Vancouver: Vancouver Centre of Excellence for Research on Immigration and Integration in the Metropolis.

Mintz, Jack M. 2000. "The February 2000 Federal Budget's Business Tax Measures: Is Canada Missing the Boat?" *Backgrounder* (C.D. Howe Institute), March 23.

Munro-Blum, Heather, with James Duderstadt and Sir Graeme Davies. 1999. *Growing Ontario's Innovation System: The Strategic Role of University Research*. Toronto: Ontario Ministry of Energy, Science and Technology.

Organisation for Economic Co-operation and Development (OECD). 1998. *Education at a Glance: OECD Indicators*. Paris: OECD, Centre for Educational Research and Innovation.

———. 1999. *Main Science and Technology Indicators 1999*. Paris: OECD Statistics.

Pearce, Ed. 1999. "Networking the World." *Ivey Business Journal*, November-December.

Personnel Systems. 1999. *Salary Increases 1997–1999 (Informatics Occupational Skills Streams)*. Report prepared for Software Human Resources Council. Ottawa.

Reallocation Steering Committee on Behalf of the Electrical and Computer Engineering Community. 1998. *Reallocation Submission: Electrical and Computer Engineering*. Ottawa: National Science and Engineering Research Council.

Rouilleault, Henri. 2000. "Work Organization and Information and Communications Technologies." In Kjell Rubenson and Hanss G. Schuetze, eds., *Transition to the Knowledge Society: Policies and Strategies for Individual Participation and Learning*. Vancouver: University of British Columbia, Institute for European Studies.

Scherer, F.M. 1999. *New Perspectives on Economic Growth and Technological Innovation*. Washington, DC: British-North American Committee and Brookings Institution Press.

Sharpe, Andrew. 1999. *New Estimates of Manufacturing Productivity Growth for Canada and the United States*. Ottawa: Centre for the Study of Living Standards.

United States. 1997a. Department of Commerce. Bureau of the Census. *Current Population Survey, March 1997*. Retrieved from Internet website: www.census.gov/population/www/socdemo/foreign.

———. 1997b. Department of Commerce. Bureau of the Census. *Statistical Abstract of the United States, 1997*. Washington, DC: US Government Printing Office.

———. 1999a. Department of Education. *Digest of Education Statistics 1998*. Washington, DC: National Center for Education Statistics.

———. 1999b. Department of Justice. Immigration and Naturalization Service. *Legal Immigration, Fiscal Year 1997*. Washington, DC: Immigration and Naturalization Service, Office of Policy and Planning, Statistics Branch.

———. 1999c. Department of Justice. Immigration and Naturalization Service. *Statistical Yearbook, 1997*. Washington, DC: US Government Printing Office.

———. 1999d. Department of Labor. Bureau of Labor Statistics. *National Employment, Hours, and Earninings*. Retrieved from Internet website: www.146.142.4.24./dsrv.

———. 1999e. National Science Foundation. *Scientists and Engineers Statistical Data System (SESTAT)*. Washington, DC: National Science Foundation, Division of Science Resource Studies. Retrieved from Internet website: www.sestat.nsf.gov.

World Economic Forum (WEF). 1999. *The Global Competitiveness Report 1999*. Geneva: WEF; Cambridge, Mass.: Harvard University, Center for International Development.

Young, Beth. 1998. "Foreign Graduate Students in the United States." In Todd M. Davis, ed., *Open Doors 1997/98: Report on International Educational Exchange, 1998*. New York: Institute of Educational Education.

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